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Procedia - Social and Behavioral Sciences 141 (2014) 1403 – 1411

Procedia
Social and Behavioral Sciences

WCLTA 2013

Kidumatica- the mathematics club for creativity and excellence among multicultural pupils: Practice and research

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Abstract

This study examined the perceptions of students, aged 10-17, who participate in "Kidumatica" a highly successful extracurricular club for mathematically talented youth. Kidumatica is marked by several unique characteristics: a fair and balanced identification system, expert mathematics instructors, personal mentoring, challenging curriculum and assignments, problem based learning, and a special assessment method known as "rating." We sought to determine how – according to Kidumatica's students, each of these separate characteristics contributes to the advancement of their creativity and excellence and thus to the club's success. Using a questionnaire analyzed through two sets of categories – one based on research literature and one on observations of Kidumatica itself – we found that Kidumatica is perceived positively overall, with success resting primarily on its challenging and innovative content, and on its problem-based pedagogy.

Selection and peer-review under responsibility of the Organizing Committee of WCLTA 2013.

Keywords: Creativity, Mathematical excellence, gifed and talented, enrichment program, multicultural pupils

Introduction

Fostering the abilities of gifted and talented youths is the purpose and the mission of Kidumatica – the mathematics club for creativity and excellence. Every year, over 500 mathematically promising students aged 10-17 participate in the club, and exercise their creative thinking in its challenging weekly workshops, monthly competitions, special activities and science field trips. This project, first conceived 15 years ago by the lead author of this paper, has become a way of life. Geographically, the club is located amongst the country's lowest socio-economic sectors, drawing in students from 26 countries of origin who speak 14 different mother tongues. Its graduates, however, have gone on to shine in the most prestigious university faculties. In addition to its educational and social functions, the club is also a 'laboratory' for experimentation in education for the talented,

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Selection and peer-review under responsibility of the Organizing Committee of WCLTA 2013.
doi:10.1016/j.sbspro.2014.05.242

from which multiple M.A. and Doctoral dissertations have already emerged.

Kidumatica's success is evident in the effect it has had on the children's social and school lives, in the achievements of its graduates, and in its victories in national and international mathematics competitions. Moreover, its popular success is manifest in its membership, which has continued to rise steadily from year to year. However, we believe that the best indicators of Kidumatica's success are the students themselves, and this study therefore focusses on their perception of the mathematics club. The purpose of this study is to use the familiarity and experience of Kidumatica's own gifted and talented students in order to identify those characteristics that – in their view – have made the math club a success.

What is Kidumatica? Identification, Activities, Structure

Kidumatica's theoretical basis

Kidumatica's basic structure was derived from the theoretical discussion surrounding the nature of giftedness and talent, and how these qualities should be identified and fostered. There are two approaches to defining giftedness in the literature. The first is quantitative; it measures students' intelligence using standard tests to detect the presence of significantly higher-than-average intellectual capacities. This approach has been found to be biased against students from more impoverished areas, or from non-western cultural backgrounds (Jackson & Butterfield, 1986, Amit, 2010). The second approach, on the other hand, is the qualitative one expressed in Renzulli's Three-Ring-Model (Renzulli, 1978; 1986), where giftedness is defined as a combination of three elements: high cognitive ability, perseverance and motivation, and creativity.

According to Renzulli's approach, gifted and talented students possess unique cognitive and personal characteristics, and therefore require a challenging educational framework adapted to their special needs (Tannenbaum, 1983; Benbow & Stanley, 1996; Mulhern, 2003; Brody & Mills, 2005; Diezmann, 2005). It is important to identify such students early (Koshy, et al, 2009), so that their talent can be addressed and fostered over a longer period of time. One of the central problems for gifted students, particularly in peripheral areas, is their inability to fully realize their potential because such cognitively challenging frameworks are simply unavailable (Diezmann & Watters, 2002; Koshy, et al, 2009; Stepanek, 1999; Guldemond, et al, 2007). Studies that address this problem stress that fostering students' talent is particularly important in socio-economically disadvantaged communities, where personal motivation for a different future can be low, and where there is consequently little awareness of the significance of identifying and developing potential of this kind. Another important element of working with talented students is social interaction, which, according to Vygotsky (1978), is central to expanding the students' abilities. The students' environment (parents, family, friends, teachers) therefore plays an important role in shaping their future (Wilder & Casserly, 1988; Ablard & Parker, 1977; Koshy, et al, 2009).

Kidumatica in practice

Kidumatica is the only project of its kind in Israel. It operates out of Ben-Gurion University, and combines its high academic standard with an atmosphere of continual challenge and fun. The purpose of the club is to foster students' thinking and their mathematical logical abilities, to promote mathematical excellence and creativity, and to provide everyone with an equal opportunity for advancement. Kidumatica is characterized by several basic elements:

1. **Identification and assessment of prospective students**: Kidumatica is meant for any student who combines great mathematical potential with high levels of motivation. Its entry exams are therefore carefully designed to bypass any reliance on culture, or on previous academic experience (Amit & Neria, 2008). In the first step of the identification process, local schools recommend students for the club, but individual applications from students or their families are also welcome. Next, the Kidumatica team invites the applicants to sit two entrance exams, which take place at the beginning of the school year (success in the first is not a necessary prerequisite to taking the second). The exam questions rely as little as possible on knowledge acquired in school, so as to minimize any bias against applicants from less prosperous schools. The test consists primarily of open-ended, non-routine questions that allow for a variety of

creative solutions and require persistence and focus to solve. Points are given not just for the final answer, but for the level of creativity shown by the student throughout the solution process.

2. Kidumatica's pedagogical paradigm utilizes the **problem based learning** approach. Its classes include almost no direct frontal teaching; instead, the students are given a problem, and work with the teacher towards its solution, acquiring and developing mathematical knowledge as they go. The skill and tools the students acquire focus on logical thinking, quantitative understanding, spatial vision, and creative use of mathematical, scientific and technological tools to complete the challenge.
3. **Content**: Kidumatica is meant to enrich its students, and so most of its content is not included in the students' formal school curriculum. This differentiation was a conscious choice, designed to allow all students to participate regardless of their previous mathematical education, and to avoid competition with the content taught in schools. The wide variety of topics covered in the club workshops includes: optimization, probability, combinatory geometry, visualization, infinite groups, logic, algorithms, combining algebra and geometry, number theory, algebraic lab, critical thinking, sets and patterns, and more.
4. The Kidumatica **teaching team** is composed of experienced teachers and mathematicians, experts in promoting excellence who love working with children. Unlike school, where one teacher must cover all of the mathematical topics, in Kidumatica every teacher specializes in their own chosen field, a field they know in depth, for which they have developed particular materials and tasks to work on with different groups.
5. **Personal attention (mentoring):** Though its instructors move from group to group, the club also includes mentors – university students from mathematically rich fields, who are often also club graduates themselves. The mentors' function is to be 'older siblings' for their students, to help them both cognitively and emotionally. The mentors remain with the same group of students for the whole year, assisting them with their classwork. They get to know their students well, and take responsibility for the attendance and the progress of each and every one. They are also the ones who (if necessary) liaise with the students' parents.
6. **Special scientific activities**: Every five weeks the club holds special activity days. These include lectures from scientists, industrialists and other experts, math Olympiads, individual or group competitions and the publication of a mathematical newspaper. In addition, club members are also taken on socio-scientific field trips to national research facilities and science museums.
7. **Structure and location**: The Kidumatica workshops take place twice a week in the afternoons, on the Ben-Gurion University campus. They are conducted in small groups, divided by age and achievement level, each with an instructor and a mentor. Because of its location inside the university, the club offers these students – and often their parents –their first glimpse of a university environment, and an opportunity to gain a familiarity with what might otherwise have seemed a strange and inaccessible place.
8. **Unique assessment method:** Club students are assessed using a specially designed 'rating system'. Each of the students begins with 1000 rating points, to which their mentors may add, based on the recommendations of instructors, or on parameters such as active participation (giving an exceptional answer or asking an exceptional question), solving homework or classwork correctly or creatively, winning competitions etc. Every day, the names of the highest 'rated' students are displayed on the bulletin board, and prizes are given to the highest rated students of the year.
9. **Prestige**: Kidumatica is a pioneer project in its field, which has garnered respect and recognition both nationally and internationally. In recent years, Kidumatica students have won national mathematics competitions and joined the Israeli national team to win international Olympiads. Advanced students have joined university classes as young students, and completed them with distinction.

Our study: Getting the students' point of view

The purpose of the study presented here was to discover which of the various characteristics that define Kidumatica are perceived **by the club members** as contributors to the promotion of creativity and excellence, and

to the club's overall success. Our central research question is: what are the main characteristics that Kidumatica's students perceive as contributing to the club's success?

The primary research tool in this study was a questionnaire. In a preliminary stage to the formulation of this questionnaire, semi-structured interviews were conducted with three doctoral students who teach in Kidumatica, and whose dissertations are based on the club's activities. These interviewees were asked to comment on a range of questions about Kidumatica, and their replies were used to refine the definition of the characteristics that this study ultimately addressed. Furthermore, we conducted close observations of the club's activities in order to become acquainted with the nature of the club, its students and its teachers*. These observation visits further focused the definition of the club's characteristics and aided in the composition of the statements in the questionnaire.

Based on the literature review, the preliminary interviews and the observations, we divided the club's characteristics into a series of categories, assigning to each a series of statements that reflect its contents. These categories were subjected to expert validation, after which a pilot version of the questionnaire was run in Kidumatica and improved upon. To strengthen the reliability of the questionnaires, about a third of the statements are phrased negatively, and were therefore calculated in reverse. We also added several statements that relate identical content, phrased in different ways. These were meant to assess whether the opinions stated by the students were their own, or merely a reaction to the particulars of the phrasing. The final questionnaire consisted of 68 statements, which were graded according to a Likert scale, ranging from 5 (I agree in full) to 1 (I don't agree at all). The questionnaire's alpha chronbach test revealed a high reliability of $\alpha = 0.89$.

Two-dimensional categorization of Kidumatica's characteristics

Kidumatica's primary characteristics, as stated above, correspond largely to those documented in the research for teaching gifted students, but not entirely. We therefore constructed an alternate version of the category distribution, which is based solely on the literature. Both versions carried the exact same statements, but in some cases these were categorized differently. Our purpose was to assess these characteristics as neutrally as possible, using the research literature to avoid any bias arising from familiarity or from our own desires. The results showed that this measure was quite justified.

The version based only on the research literature (Version A) consisted of ten categories that potentially contribute to the success of Kidumatica as a project to promote gifted and talented students:

1. Method of identification and acceptance of new gifted students
2. Generating a framework that fosters mathematically talented students
3. Influence of this framework on:
    a. Socio-emotional aspects b. Self-image c. Cognitive ability
4. Impact of students' environment on their participation in the fostering framework
5. Evaluation:
    a. Is appropriate and fair
    b. Encourages learning
6. The fostering framework as a source of enrichment separate from school
7. Facing challenging tasks
8. Formative assessment (by the teacher/mentor)
9. Teaching staff suitable for fostering talented students
10. Location of fostering framework and activity timetable.

The second version (Version B), which was based upon the authors' interviews, observations and experience in Kidumatica, contained the following 8 categories:

1. Kidumatica's Problem Based Learning approach to teaching
2. Method of identifying gifted students for admittance
3. Content – the topics covered in the mathematics club

* The primary author of this paper has, as the Kidumatica's founder, been an active participant in its activities since its inception. She is therefore intimately familiar with all aspects of the club.

4. Personal attention from the mentors
5. Alternative 'rating' assessment method
6. Influence of the club's society, location and prestige on club members
7. Instructors who are expert in their field
8. Why Kidumatica? Personal reasons for joining the club.

Appendix 1 presents a table that shows how the questionnaire's statements are distributed between the categories in each of the two versions. The lines in the table represent Version A (the literature-based categories), while the columns represent Version B (the Kidumatica-specific categories). For each statement in the table, the grey square indicates where it was categorized in the two versions.

In some cases, the differences between the categories in the two versions changed the distribution of the statements. For example, Version A placed the two statements "It is important that the mentor be in touch with my parents," and "My environment (family, teachers, friends) respects me more because of Kidumatica" together in the category "Environment's impact on students' participation in the fostering framework," while Version B placed the first in "Individual attention from the mentor" and the second in "Influence of the club's society, location and prestige on club members." In other cases, however, the distribution remained similar. Both versions, for example, placed the three statements "teachers in Kidumatica are better than the teachers at school," "the teachers in Kidumatica have extensive knowledge in math and other fields," and "I feel that the teacher cares whether or not I understand the material" in a single category: "Teaching staff suited to teaching the gifted" in Version A, and "Instructors who are expert in their field" in Version B.

Results and analysis

To determine the students' perceptions as to which characteristics were important to Kidumatica's success, we calculated the average response for each category to the statements that reflect its importance (the students' answers were given on a 1-5 Likert scale). Table one presents the averages and standard deviations for the categories in Version A (the categories derived from the research literature). It shows a generally high level of agreement regarding the importance of most of these categories in Kidumatica.

Table 1: Agreement level results for literature-based categories

CATEGORY – RESEARCH LITERATURE BASED	AVG (SD)
1. Method of identification and acceptance of new gifted students	3.30 (0.56)
2. Generating a framework that fosters mathematically talented students	3.69 (0.91)
3. Influence of this framework on:	
a) Socio-emotional aspects	2.80 (1.07)
b) Self-image	3.19 (0.75)
c) Cognitive ability	3.56 (1.34)
4. Impact of students' environment on their participation in the fostering framework	2.74 (0.82)
5. Evaluation:	
a) Appropriate and fair	3.72 (0.83)
b) Encourages learning	3.21 (1.02)
6. The fostering framework as a source of enrichment separate from school	3.64 (0.56)
7. Facing challenging tasks	3.93 (0.54)
8. Formative assessment (by the teacher/mentor)	3.45 (0.66)
9. Teaching staff suitable for fostering talented student	3.49 (0.69)

(N=286)	10. Location of fostering framework and activity timetable	2.54 (1.13)

Table 2 shows the averages and standard deviations of the Kidumatica-specific, experience-based categories in Version B. It too shows a high level of agreement in most categories.

Table 2: Agreement level results for Kidumatica-specific categories

	CATEGORY – KIDUMATICA SPECIFIC	AVG (SD)
1.	Kidumatica's Problem Based Learning approach to teaching	3.68 (0.53)
2.	Method of identifying gifted students for admittance	3.26 (0.56)
3.	Content – the topics covered in the mathematics club	3.83 (0.56)
4.	Personal attention from the mentors	3.43 (0.77)
5.	Influence of the club's society, location and prestige on club members	3.19 (0.75)
6.	Influence of the club's society, location and prestige on club members	3.04 (0.70)
7.	Instructors who are expert in their field	3.52 (0.76)
8.	Why Kidumatica? Personal reasons for joining the club	3.75 (0.85)

(N=286)

In table one, the categorization is wholly based on the research literature on giftedness, and applied to the case of Kidumatica. In table two, the categorization is derived from characteristics that were gleaned from experience with the club's activities. Both tables indicate a high level of satisfaction on the part of the students with the Kidumatica model, and the project as a whole comes across as a success. The correlation between the two categorization versions suggests that the model developed in Kidumatica for working with gifted and talented students is extendable beyond the specifics of a single instance, and applicable to universal studies in this field – it is successful both in its own specific terms, and in those derived more broadly from others' research.

A closer examination of the results clearly indicates that the club's challenging mathematical tasks and interesting content are a central pillar in its members' perception of its success. In other words, challenging problems, innovative topics, content not found in the school curriculum and problem based pedagogy – all of these make up the core of the program's success. The extensive knowledge and experience of the teachers, each of whom is an expert in their own field, is another central element in Kidumatica's success.

On the other hand, Kidumatica's location inside the university and the impact of the students' environment are shown in both versions to have relatively little impact as far as the students are concerned. This is possibly due to the fact that the club participants have become accustomed to being on the university grounds, and therefore attribute little importance to being there. Furthermore, it is also possible that they have no alternate location to compare it to. This point requires further investigation.

The results of this study were tested with different student populations: boys and girls, beginners (first year), continuers (second year) and veterans (third year onward), and students from different cultural backgrounds. No significant differences were found between any of these groups. This suggests the further possibility that Kidumatica's methods bridge those differences that are often expected to arise in mathematics (particularly among gifted students) between genders and between cultures. The lack of difference between groups with different tenures may indicate that Kidumatica's success factors are maintained over time, with the club keeping its students interested and challenged by continual innovation.

In conclusion, the results of our study reveal Kidumatica, the mathematics club for creativity and excellence, as an enrichment program that offers fertile ground in which to foster the development of gifted students on their way to realizing their potential. The universality of the results and their solid connection to the research literature point to the possibility of applying the Kidumatica method to other places in the world where there is a need and a desire

to foster the talents of the mathematically gifted. Over the years, Kidumatica played a key role in the development of thousands of stellar students, and it doing so it has established itself a practical model for the promotion of youthful excellence.

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Appendix 1: categorization of statements in both versions

Categories based on research literature (Version A)			Item #	statement	Categories specific to Kidumatica (Version B) *							
					1.PBL	2.identifying gifted students	3.content	4.Personal attention	5.'rating'	6. society, location and prestige	7.Instructors who are expert	.8 why Kidumatica?
	1. Method of identification and acceptance of new gifted students		7	The need to take two entrance exams does not minimize test anxiety		■						
			68	In my opinion, school recommendations are enough for club admittance and there's no need for tests		■						
			48	I think the Kidumatica entrance exams are important to keep up the club's high standard		■						
			39	The mathematics I learned in school did not help me in the club entrance exams		■						
			66	I was surprised by the Kidumatica entrance exam questions		■						
			53	Explaining your solution in words in the entrance exam is unnecessary		■						
			38	There's no need to study for the Kidumatica entrance exams		■						
			49	I'm in the club because I enjoy solving math problems								■
	2. Generating a framework that fosters mathematically talented students		61	In Kidumatica students participate in the learning more than they do in school	■							
			1	I like the way they teach in Kidumatica	■							
			55	Kidumatica has made me more interested in mathematics						■		
			6	I'm in the club because being in Kidumatica will open more options for me after high school								■
	3. Influence of this framework on:	a) socio-emotional aspect	8	I would recommend being in the club to my classmates						■		
			52	The club is not fun for me socially						■		
		b) self-image	19	When I come to the club at the university, I feel like a university student						■		
			5	I'm in the club because the club is prestigious						■		
			25	I feel proud to be part of the club						■		
			35	I'm in the club because I'm good at math								■
		c) cognitive ability	28	I feel that the teaching methods in Kidumatica help me in school mathematics too	■							
	4. Impact students' environment on their participation in the fostering framework		16	It is important that the mentor be in touch with my parents				■				
			44	I share the 'rating' results with my parents					■			
			43	My environment (family, teachers, friends) respects me more because of Kidumatica						■		
			60	My friends think Kidumatica is prestigious						■		
			9	I'm in the club mostly because my parents want it								■
	5. Evaluation:	a. Is appropriate and fair	27	I would prefer tests instead of 'rating'					■			
			63	I understand how and why the 'rating' is given					■			
			51	The 'rating' is distributed fairly					■			
			46	The 'rating' is not fair					■			
			3	'Rating' is unnecessary					■			
			34	The 'rating' does not reveal the strongest math students in the group					■			
		b. Encourages learning	10	I don't care if my 'rating' is high					■			
			57	The 'rating' creates a negative tension in the students (makes them anxious)					■			
			13	I look at the 'ratings' table at every meeting					■			

			59	The 'rating' encourages me to learn more	**Categories specific to Kidumatica (Version B) ***							
Categories based on research literature (Version A)	Categories		Item #	statement	1.PBL	2.identifying gifted students	3.content	4.Personal attention	5.'rating'	6. society, location and	7.Instructors who are expert	.8 why Kidumatica?
	6.The fostering framework as a source of enrichment separate from school		30	The methods taught in Kidumatica are like the ones taught in school	■							
			29	In Kidumatica we do not repeat problems assigned for homework	■							
			64	In Kidumatica we show different ways of solving problems	■							
			47	I like the format of the Kidumatica workshops	■							
			56	I like the format of the Kidumatica activity days	■							
			45	Activity days are unnecessary, we do not learn anything new	■							
			21	In school we discuss different ways of solving math problems	■							
			11	In school we decide for ourselves how to solve complex math problems	■							
			31	Most of the topics taught in Kidumatica are not taught in school			■					
	7. Facing challenging tasks		12	In Kidumatica, "we don't just calculate – we think". Do you agree?	■							
			14	In Kidumatica we deal with complex problems	■							
			42	In Kidumatica the math problems are more challenging than the problems in school			■					
			50	In school we solve problems like the examples in the book			■					
			4	In Kidumatica we mostly learn formulas by heart and repeat them			■					
			58	In school we mostly learn formulas by heart and repeat them			■					
			26	The material in Kidumatica is easier than the material at school			■					
			24	Problems in Kidumatica are like the problems we learn in our textbooks			■					
	8.Formative assessment (by the teacher/mentor)		17	In school we do not discuss our solutions to problems we do in class with the math teacher	■							
			54	In Kidumatica we talk about our solution path	■							
			33	The mentor is unnecessary in the group I am learning in				■				
			65	The 'rating' does not reflect my knowledge in Kidumatica					■			
			41	The 'rating' reflects effort in Kidumatica					■			
	9.Teaching staff suitable for fostering talented students		32	If I am gone from the club, the mentor takes an interest in my wellbeing when I get back				■				
			20	I would want to be a Kidumatica mentor too				■				
			23	The mentor gives me individual attention				■				
			37	Schools should have mentors too				■				
			2	Mentors do not contribute to my understanding of the material				■				
			40	Kidumatica teachers have extensive knowledge in math and in other fields							■	
			62	The teachers in Kidumatica are better than the ones at my school							■	
			36	I feel that the teacher cares whether or not I understand the material							■	
			18	I would not want my school teacher to be like the teacher in Kidumatica							■	
			22	I would prefer to have separate teacher I would not want my school teacher to be like the teacher in Kidumatica							■	
	ation of fostering framework and activity timetable.		67	The club's location at the university is important to me						■		
			15	I do not care that the club is in the university and not at school						■		

* יפכ האלמה הירוגטקה משרמאמב עיפומש